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ABSTRACT

Based on findings that poorer schools tend to use computers mainly for drill work, while richer ones often use them for other purposes, such as supporting research and creativity, this project aimed to increase the understanding of how to best support teachers in inner-city schools. The project worked intensively with teachers from two inner-city elementary schools on using computers to enhance a problem-solving, cooperative approach to education. Teachers were trained while they had computers in their homes, helped to integrate computing into their curriculum, and supported while they implemented their plans. Results include findings about how best to teach teachers about new software, how long it takes teachers to learn about and use computers well, and how best to support teachers while they implement classroom plans. Learning to use new software proceeds in stages, and may require years for teachers to feel completely comfortable with sophisticated applications. Learning how to use computers and software is often much easier in collaboration with others than learning alone. Time spent with a computer at home helped build teachers' confidence for use in schools. Theoretical and practical learning about software, inside and outside the classroom, should be ongoing. Diffusion of interest about using computers can spread throughout a school, based on interesting projects some teachers are involved in. Schools need to provide time for teachers to learn about computers, and teachers will integrate computing into the curriculum in different ways. The paper includes an executive summary. (SWC)

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ED 414 881

Teacher Training for Using Computers in Minority Education

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Teacher Training for Using Computers in Minority Education

FIPSE Award Number P116B91293

Project Summary

Our project worked intensively with teachers from two inner-city elementary schools on using computers to enhance a problem solving, cooperative approach to education. In a series of phases, we trained teachers while they had computers in their homes, worked with them on integrating computing into their own curriculum, and supported them while they implemented their plans. Results included findings about how best to teach teachers about new software, how long it takes teachers to learn about and use computers well, and how best to support teachers while they implement classroom plans.

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Executive Summary

Project Overview

Based on findings that poorer schools tend to use computers mainly for drill work, while richer ones often use them for other purposes, such as supporting research and creativity, this project aimed to increase our understanding of how we can best support teachers in inner-city schools. Working collaboratively with a core or upper elementary teachers in two school's near us, we developed techniques for training teachers and working with them in integrating computing into their curriculum, emphasizing skills of problem solving and cooperative learning. Outcomes of the project include, first, a set of findings about how teachers learn to use computers, how they use them, how specific school situations influence teachers' use of computers, and how outside experts can work collaboratively to support teachers. Second, the project has resulted in institutionalization and integration of these findings. Third, products from the project include a set of curriculum units (in preparation), developed by project personnel and teachers, on using computers to enhance collaborative problem solving.

Purpose and Background

Through fifteen years of working with teachers, administrators, and computer coordinators of urban and suburban school districts, the Program in Computing & Education at Teachers College has noted inequities in the way richer (mostly suburban) and poorer (mostly urban) schools tend to use computers. While the latter mostly use them to reinforce basic skill in the form of drill work, in the former at least some students often use computers to practice higher-level thinking skills and creativity. Although it is possible that all schools will achieve equity in the numbers of computers per student, at the same time the inequity in kind of use may remain constant, thus exacerbating an inequity in the quality of students' education. This project assumed that all children can benefit from cooperative problem solving activity at any level, and that computers ought to be an invaluable aid in this enterprise.

One reason for this inequity is the common assumption that poorer students need drill in basic skills before moving on to higher-level thinking activities. Research in cognition, however, points out that both kinds of thinking are necessary, and in fact are combined in actual practice. Other research in school practice, moreover, shows

that the same students who lack basic skills in the younger grades seem to have the same need in high school (if they stay in school that long) and therefore receive the same kind of instruction in lower-level thinking.

Another reason schools tend to gravitate toward drill and practice software has to do with the structure of schooling. Such software tends to fit better into current curriculum, breaking curriculum down into a set of discrete skills that can be taught one at a time. Further, it requires less learning time for teachers and less classroom time for students. Both school in-service training and typical college courses thus concentrate on software that is easiest to learn and cover, ignoring other software that may be of much greater value. These approaches integrate computing into curriculum by handing teachers ready-made instructional software that, like most curriculum packages, give teachers little input into how and what they teach.

This project aimed to address these conditions by exploring how teachers in inner-city elementary schools can best learn and use software to support cooperative problem solving activities. It supported teachers in making their own decisions, based on what they had learned, about using computers in their own curricula. Finally, it aimed to decrease teacher isolation by networking teachers with their peers from the same and other schools, with outside experts, and with others on a computer bulletin board.

Project Description

With computers donated by Apple Computer, a core group of teachers went through three phases: 1) intensive training workshops at Teachers College, while learning to use computers in their homes; 2) planning and beginning to use computers in their classrooms; 3) design and implementation of curriculum projects using computers. In all phases teachers were supported by project personnel.

The second half of the project followed the same pattern as the first for the newly added group of teachers, with the original core group of teachers available for support within the school. During the second half, project personnel continued to work with core teachers as they extended and deepened their knowledge about computing in the classroom and developed new and more comprehensive curriculum projects.

Project Results

Findings from the project fall into two headings, teacher learning about computers, and work with schools. Elements of the former include:

1. For new users, learning to use software proceeds in stages and may, in fact, require years for teachers (or others) to feel completely at home with sophisticated applications.

2. Learning how to use computers and software is often much easier in collaboration with others that learning alone. Teachers, often isolated in their classes, need a support structure to learn and use computers effectively.

3. Time spent with a computer at home helped build teachers' confidence for use in school. Teachers need not only sufficient learning time, but also easy access to computers.

4. A variety of ways to learn about software can facilitate acquisition and integration of new concepts. Theoretical and practical learning, both in and out of the classroom, should be ongoing and support one another.

Findings about working with teachers in school settings include:

5. Diffusion of interest about using computers can spread throughout a school, based on interesting projects some teachers are involved in.

6. Schools need to provide time for teachers to learn about computers, and this often requires creative uses of smaller or larger blocks of time.

7. Each teacher, classroom, and school is unique, and teachers will therefore, if given authority to make decisions about their curriculum, integrate computing into it in different ways.

Conclusions

Our findings have implications for three areas of eduacational computing:

First, incorporating computing into the fabric of school life is not easy. Institutionalization within schools requires an ongoing school commitment, and an ongoing support structure to continue the effort.

Second, knowledge of how teachers best learn about computing can help in the integration effort. Teachers need a variety of learning opportunities, and these can be facilitated by the provision of outside expertise.

Third, implications for schools of education are that prospective (and current) teachers should model the ways we expect them to teach with computers, they should study the structure and the culture of schooling to understand the difficulties as well as the possibilities of integrating computing into education, and they should have actual experience working in school computing situations.

Project Overview

Based on our previous work in educating teachers about computers through courses and workshops, this project explored and tested a collaborative relationship between Teachers College and two inner-city elementary schools. Out of concern that poorer schools have been using computers mainly as a reinforcement for drill work and lower order thinking skills, the project focused on cooperative learning and problem solving applications for computers in elementary school curriculum. Working intensively with small numbers of teachers from each school, the project sought to build interest and expertise among the schools' faculties, in order to empower them to make effective decisions about how to integrate computer work into their own curricula.

The project's overall goal was to increase our understanding of how teachers can best learn to use computers well in their teaching, so that this knowledge might become integrated into our future work with teachers. To this end we worked closely with a core group of teachers, and later with additional teachers from each school, first teaching them about a variety of computer applications, then planning curriculum units and helping them implement these units in their classrooms. We also studied teachers' attitudes toward using computers in education, their increasing knowledge about computer software, and the effects of a variety of ways of working with teachers to support them in their efforts to implement computer activities.

Outcomes of the project include, first, a set of findings about how teachers learn to use computers, how they use them, how specific school situations influence teachers' use of computers, and how outside experts can

work collaboratively to support teachers. Second, the project has resulted in institutionalization and integration of these findings. Third, products from the project include a set of curriculum units (in preparation), developed by project personnel and teachers, on using computers to enhance collaborative problem solving.

Purpose and Background

Our motivation for exploring new approaches to teacher education stemmed partly from fifteen years' experience working with teachers and computer coordinators, locally and nationally. Through a variety of courses, workshops, seminars for computer coordinators, and an intensive degree program for teachers from around the world, our department has been exploring different methods of educating teachers and policy makers about technology. Because none of the states around us require certification for teaching with computers, however, we have not had an official program in which we and our students work in schools. Our experience with inservice courses or workshops offered by schools or school districts showed that these taught (typically) only the easiest kinds of software applications, or those which fit most easily into existing school curriculum.

In our judgment, both of these types of computer education -- traditional university offerings and inservice courses -- were inadequate for two reasons.

They ignored both the potential of the technology in itself and its potential for helping to transform curriculum.

Throughout most of the 1980s, the number of computers in United States schools nearly doubled each year. Early in this growth a disparity between richer and poorer school districts became noticable -- richer districts had more access to certain kinds of funding, more connections with the computer industry, and possibly more financial support from parents. Equity, in terms of equal access to computers for all students, became an important issue, grounded in the longstanding American belief in equal opportunity in schooling.

Equity, however, involves not only how many computers are in schools, but what they are used for. Recent studies have shown that in poorer districts student use of computers, when it occurs, involves mostly drill work, while in richer districts students often use spreadsheets, databases, simulations, programming, and other computer applications designed to enhance their creativity or research skills. Educators' rationale for this dichotomy is usually that poorer students tend to lack "basic skills" in reading and math, and that computer-assisted instruction can provide tutoring in these areas. The problem with this rationale is that the same poorer students who get basic drill and practice remedial work in the lower grades are typically doing the same kind of activity in later years, if they are still in school. In fact, the belief that so-called "lower level" thinking skills can be totally separated from "higher order" thinking is a fallacy that serves to perpetuate the dichotomy in educators' thinking about poorer and richer students. In reality, all students can think, and do so all the time, normally combining "higher" and "lower" skills.

The different computer applications mentioned above also typically involve students in different ways of working together. Whereas the more creative applications often lend themselves to student interaction, drill and practice is usually seen as individual or even competitive work -- microcomputers or larger systems with terminals deliver drill work to individual students whose progress is measured and reported. Researchers have found that any use of computers tends to motivate students to interact spontaneously. Nevertheless, without conscious teacher attention to, and structuring of, such interaction it can be relatively worthless, and in the context of drill work especially teachers tend to discourage any interaction.

At the present, in the beginning of the 1990s, the disparity in numbers of computers seems to be diminishing, and many educators believe that through a combination of public and private donations the number of students per computer will tend to equalize throughout all districts. The question of how different students will use computers remains, however, and is crucial. The present dichotomy of use, if continued, will serve only to exacerbate further the quality of education between rich and poor districts. Computers are potentially powerful and empowering tools, but using them only as remedial tools will result only in extending the differences in schooling for rich and poor.

This project, then, aimed to explore an intensive kind of collaborative work with teachers in schools, with the purpose of enabling these teachers to use computers expertly and in such a way as to empower their students to become collaborative problem solvers. Since teachers themselves have had little opportunity to collaborate or solve problems in their own professional work, a

necessary component was to give teachers the opportunity to develop these skills. We posited that, in order for teachers to become effective decision makers about computers, they needed three kinds of experience: 1) to become familiar enough with hardware setup and aspects of troubleshooting so they would feel confident about having a computer in their classroom; 2) to be experts at using any software application they intend to use with their students; and 3) to understand the theoretical and practical backgrounds of problem solving and cooperative learning, and how software relates to them. This we tried to accomplish through intensive workshops with the teachers, through individual meetings and planning with them, and through networking them with each other for support and communication.

We deemed communication and collaboration between project teachers to be an essential component. An often cited problem in teacher planning is teachers' isolation from one another, both in terms of learning about what other teachers are doing and in working with other teachers. This project tried to overcome teacher isolation in several ways. Workshop meetings provided opportunities for discussion between teachers in two schools. Work with project personnel, in workshops and in their classrooms, provided teachers support and ongoing discussion. Finally, an electronic bulletin board that we operate was available to teachers for communication not only with others in the project but with teachers from around the country. Thus, a variety of methods of adult learning was facilitated by several kinds of collaborative work among adults.

Project Description

Apple Computers gave the project fifteen Apple IIGS's, along with modems and printers for each computer. This donation made it possible to explore the effect of allowing teachers to take computers home for a period of time, and to experiment with different configurations of computers within the two schools.

The project began with a year and a half of intensive work with a core of three teachers from each of two inner city elementary schools. The second year and a half added a number of other teachers from each school to the group. Our only criteria for selecting teachers were that they had little or no prior experience using computers and that they were interested in exploring how computers could facilitate collaborative problem solving.

Each half of the project consisted of three phases, corresponding to three semesters:

First semester: Teachers took their Apple IIGS's and printers to their homes and spent one day a month at Teachers College working with project personnel to learn how to use them. This included learning to set the computers up, to troubleshoot problems in their operations, and to use different software applications such as databases, simulations, word processing and desktop publishing. It also included readings and discussions on computers and collaborative learning.

Second semester: Teachers took their computers to their classrooms and tried out various applications with their students. Project personnel

were available for help in schools -- assisting teachers, modeling lessons with students, and sometimes working with groups of students, and meeting with teachers to discuss progress.

Third semester: After a year of becoming familiar with computers, teachers designed their own curriculum projects for use with their students. Project personnel remained available for assistance.

The second half of the project followed the same pattern as the first for the newly added group of teachers, with the original core group of teachers available for support within the school. During the second half, project personnel continued to work with core teachers as they extended and deepened their knowledge about computing in the classroom and developed new and more comprehensive curriculum projects.

Project Results

Since the desired outcome of the project was to enable us to educate teachers about computers so that they might use them more effectively in their schools, the primary object of research was to investigate teacher learning. Since the context of the project was school settings, this necessarily involved studying both the individual learning process and how teachers learn and implement computer curriculum in real settings.

We tried several evaluation techniques. One that we found not appropriate for the project was a questionnaires called Stages of Concern and Levels of Use that were designed to measure the process of adopting innovations in schools. We had planned to administer these instruments three times, at the beginning, middle, and end of the project. We found no significant differences in the answers between the first and second administration to the core group of teachers. Interviews with these teachers revealed that they had two kinds of problems with these tools. First, the questionnaires were generic, referring constantly to "the innovation." They were not developed for a particular type of innovation like the computer. Teachers had difficulty in many cases substituting "computers" for "the innovation" because often the meaning of question was not even clear when thinking about it in terms of computers. Different or more clearly phrased questions would have been needed in our case. Teachers' second objection was to filling out a fairly lengthy questionnaire in the first place. Teachers tend to resent the amount of form and paper work laid upon them, and it was not clear that they even gave the questionnaires much of their attention.

Since the number of participants in the study was so small, we decided that the kind of information we had hoped to collect from these questionnaires could be gathered as well, or perhaps even better, using other evaluation techniques. First, we interviewed each teacher formally at the end of each year (and new teachers also at the beginning of their involvement) about their attitudes about computers, how these had changed, what worked well and what didn't, and so forth. Second, project trainers met regularly with teachers to plan, and kept notes of their conversations with teachers. Third, trainers visited

classes frequently and thus had the chance to observe teachers' use of the computers and keep track of their progress and difficulties.

Findings from the project are discussed below under two general headings, teacher learning and work with schools. Although these categories necessarily overlap, there are clear differences between individual learning and the kind of learning and implementation that is affected by the school context. Since the number of teachers involved was small, findings are presented in discussion form and not in statistical tables.

Teacher learning

1. Stages, and length, of teacher learning. Like other kinds of learning, the learning of software proceeds in stages. Trying to "teach" computer-naive teachers to use sophisticated applications is usually doomed to failure. A certain period of time to integrate new experiences at one level is necessary for teachers. Beginning with an easy desktop publishing program, for instance, will increase teachers' confidence and, once they run up against its limitations, will whet their appetites for software that does more. Most teacher training programs avoid this problem by sticking to easy-to-learn applications. Evidence from our studies with project teachers, however, indicates that by the end of one year most teachers were beginning to feel comfortable with computers and software, and to believe that they could learn new software by themselves. This is not to say that teachers were completely at ease, only that they now felt ready to proceed on their own to a more complex word processor or database program. They had, that is, become more confident and self-directed learners.

In fact, we started our training work with the initial error of assuming that, since we were working intensively with a small core group, we could begin by showing them impressive and sophisticated software. Most teachers in the group, however, appeared confused and expressed the desire to begin with "simple" software that did not require a large leap from software they were used to. It appears, then, that teachers need much longer than is usually realized or provided to move from simpler to more complex software, gradually integrating new features and capabilities along with new complexities. The reason we want teachers to use more sophisticated software is because of what such software can do and how it relates to collaborative problem solving situations. Databases, production tools, and simulations are powerful tools for learning and for collaboration but they may take at least some teachers a while to learn and to feel comfortable about using them.

2. Collaboration in teacher learning. One clear finding of the project is that, at least in a new and different area like software, learning together is often much easier than learning alone. Supported by project personnel (in workshop sessions, on the telephone and bulletin board, and in classrooms) and by their colleagues (who are available daily for help and discussion), teachers have not only ready support but also motivation to think about and keep using software. Teachers need more support in the beginning stages of learning about computers and software, and as they become more confident (as noted above) learning alone becomes more practical and often more productive. In a larger sense, though, teachers need a structure of ongoing support and networking with other teachers and outside experts that they rarely experience. We need to build as much adult collaboration as possible into teacher education and teachers' work

in school, for continuous learning, discussion, and planning, and also so that in their own practice they learn to model what they expect of students.

3. Transfer from personal learning to teaching. This project assumed that a good way to build teachers' technological expertise was to send computers to their homes for a period of time. If this is true, the question remains whether, and how well, this learning transfers to using computers in classrooms. Based on observations, questionnaires, and in-depth interviews we have conducted with teachers, it seems that the confidence built in the time teachers had to learn at home did help equip them for bringing their computers to school. Problems with hardware and software of course arose, but teachers now either knew how to handle them or to look for help. An implication here is that teacher education programs should provide teachers not only sufficient time to learn, but also some kind of easy access to computers so that teachers will use them outside of the classroom.

4. Varieties of learning. A variety of ways to learn often facilitates acquisition and integration of new concepts, for adults as well as children. This project provided not only different forms of collaboration between adults, but also, as described above, several ways for teachers to learn within the classroom. The assumption was that theoretical learning (in this case learning to use software at home, and thinking about using it with students) should be linked with the more practical learning that comes from actually trying out software in class. Because in-service is usually offered as courses, it often has difficulty connecting teacher learning to actual practice. This project combined laboratory learning and discussion with supported practice in teachers' classrooms.

Ongoing discussions with project teachers indicate the benefits of tying together many kinds of learning. Not only do theoretical and practical learning continually reinforce one another, but both should be ongoing -- our teachers see themselves as learners as well as teachers, learning from students as well as other adults. Though they feel a degree of competence, continuous discussion and experimentation continue to give them a personal sense of growth and discovery.

Work with schools

5. Diffusion of interest within schools. One of the hypotheses of this project was that an infusion of expertise and long-range support from outside the school would help build a lasting interest and knowledge base within the school, so that effective use of computer technology would continue to grow after the project. This hypothesis was partly confirmed.

On the positive side, interest did grow. One condition of this project was to include only teachers who were interested in it and wanted to be involved. When we reached the second half of the project, in which we were to expand the group within each school, we found that there were more teachers interested in joining than we anticipated. This resulted from knowledge that spread around the school about what our core group was doing (and perhaps also from the desire to have a computer at home). Such interest suggests a number of points. First, teachers are naturally interested in a project that works. Second, the voluntary nature of a project -- the opportunity to see, or hear about, it without feeling compelled to be part of it -- can engender interest and enthusiasm.

Third, and possibly most crucial, a necessary element may be the long-range partnership with an outside agency like a school of education which can help teachers learn in an unthreatening way and continue to support them and help them develop.

On the negative side, we did not anticipate such a large teacher turnover as we experienced. In one school, none of the original core group was left by the third year, and in the other almost half of the core and the additional teachers were not in the school by the end of the three years. These developments forced us to revise our original schedule, sometimes adding new teachers in the middle of the year, and causes frequent improvisations in the way we trained teachers, such as organizing shorter, individual sessions and arranging for more experienced teachers to work with colleagues just learning about computers.

We would characterize the net accomplishment as positive, with use of computers still rising in each school. It is possible that the seed we planted is strong enough to take permanent root. It is also possible, however, that in the school with the higher rate of teacher turnover (the school with the poorer student population) so many teachers we trained will leave that little tangible training results will remain. In this case it may be necessary to build much stronger internal mechanisms for training and networking than we were able to do.

6. Time for learning. One of the crucial elements in learning something new and unfamiliar, or in planning well to use something one already understands, is having the necessary time. Traditional American schools are notorious for providing teachers very little time for preparation, learning,

meeting with colleagues, or other kinds of planning. One of the components of this project was the provision of some learning and planning time.

First, sending the computers home with teachers for a term theoretically gave teachers extra time to learn and practice. (In fact, it may have also created feelings of anxiety and guilt when teachers felt they were not putting in enough time at home.)

Second, the original plan called for one day per month of released time. We held to this plan for the first project year, although it was often difficult for school administrators to cover classes for these days. The end of the first year was a time of large school budget cuts. Therefore, we revised the original plan and for the second year we asked principals to arrange half days instead of full days for teachers to come to Teachers College. This meant using coverage that was already in place in the schools instead of having to hire substitutes for full days and thus saved school funds. Since the schools we were working with are close to us, travelling to and from school for half a day was not a hardship for the teachers. In the third year the budget situation became even more serious, and we became more creative in arranging times to work with teachers. Since we already knew all the teachers personally we no longer went through school administration but arranged free blocks of time with teachers, singly or in groups. This proved much easier, on the one hand, in terms of making arrangements (which had been difficult for administration to do) and also proved more satisfactory to teachers. They made whatever arrangements they had to make to clear an hour and a half or two hours, and we were flexible enough to be able to meet at odd times.

The change from the first year to the third consisted chiefly in meeting with smaller groups for particular needs instead of planning long sessions for everyone all together. The content of the third year's meetings were dictated partly by teachers' needs and partly by what we offered to do with them. They consisted of planning meetings, learning new software, or discussing problems. We found them more personalized, more individualized, more effective in their use of time. Further, they increased communication between us and teachers, and they eliminated travel time for teachers.

7. Different school and classroom cultures. Finally, we want to emphasize the uniqueness of each school, and even each particular classroom, in planning activities. The small number of core teachers in this project allowed us to relate personally and intensively to each, in discussions, workshops, and visiting and working in their classrooms. From this experience we found confirmation of what should be an obvious principle of educational planning but is often ignored -- that each classroom is a unique cultural and educational setting, created and influenced by factors within and without the classroom. Teachers in our project, for instance, varied remarkably in their interest in computers, their anxieties about them, their success in learning about them, as well as in the need they saw to use them in collaborative situations in their classrooms. Teachers' curricular objectives for their classes also varied, based on teachers' interests and concerns of their students, as well as schools' expectations. Some variation between schools was also noticable. For instance, at one school, in one of the poorest areas of New York City, teachers perceived that their students' access to libraries was declining because of cuts in library

service, and so they decided to emphasize software that helped students do research.

Institutionalization and Continuation

The work begun in this three-year project is becoming part of our work at Teachers College in several different ways:

1. *Development of curriculum modules.* As part of our work in schools, project personnel helped teachers develop curriculum units using several kinds of software. All of these emphasized the use of computers in collaborative, problem solving situations. Examples are students' collection of data to create databases about animals, use of prepared databases to investigate and compare nations of the world, creation of software cartoons with younger children, and publication of class or school newspapers. These units are in process of being formally compiled and written up by the project coordinator, for use in department courses and for possible dissemination or publication.

2. *Incorporation into coursework.* Besides the curriculum units mentioned above, experience and results from the project are being incorporated into department courses. First, course pedagogy has in many cases been revised to permit greater hands-on and experiential learning about uses of computers for collaborative problem solving. Second, an improved understanding of how novice computer users can best learn software, including collaborative work, has benefited many of our courses.

3. *Placing of interns.* Partly as a result of this three-year project, we have begun placing students as interns in school settings. Since there is no certification in computer teaching in New York State we have no formal student teaching arrangements, but through contacts with area schools we are placing interns in situations we judge will give them valuable experience working with children and teachers.

4. *Continuing work and research on collaboration and problem solving.* Through courses, workshops, and work in schools we are continuing to study how students and teachers can use computers to enhance cooperative problem solving. In the last year of the project, through a small amount of seed money provided by FIPSE, we began developing an interactive videodisc on this topic, for use in our courses and for broader dissemination as a teacher training tool. We are currently working on editing footage gathered last year and in seeking additional funding.

Conclusions

Our findings in this project have implications for three areas of computing education: 1) the institutionalization of computers in schools; 2) teacher learning about computers; and 3) necessary ingredients of a teacher education program in computing.

First, incorporating computing into the fabric of school life is not easy. Because of the low priority that the use of computers has at most schools, the lack of understanding about computers on the part of most teachers and

administrators, budget constraints, as well as the rapid rate of teachers turnover at many inner city schools, computing has not made great inroads into instructional practices. Where it has succeeded it has used the traditional drill and practice, basic skills reinforcement model that is easy for schools to understand and implement. The establishment of an alternative model for integrating computing, as this project has tried to do, probably depends on the concurrent reorientation of a school's entire way of thinking about instruction and learning. In other words, for computers to be used effectively to enhance collaborative problem solving, the school must emphasize this approach in other areas as well. It must allow teachers to work collaboratively on meaningful curriculum and governance problems with their peers, and it must value this kind of experience for students also. Our project, in spite of its successes in schools, probably shows the limits inherent in outside experts working with teachers. Institutionalization within schools requires an ongoing school commitment, and an ongoing support structure to continue the effort. In such a case a school might very well continue to work collaboratively with outsiders, but it would not depend on them entirely for success.

Second, this project discovered and confirmed much about the way teachers learn about using computers. It showed, as others have found, that teachers pass through stages of learning about complex software, based on their familiarity with computers, their confidence and sense of ease about them, and their perception of the value of computer applications to their curriculum. All of these factors need time to internalize, and it is this time that schools rarely provide. The project also demonstrated a variety of methods in which teachers can be supported in their learning, from workshops outside the school to

occasional assistance in their classrooms. Much of this support could be provided within a school, by means of peer support groups and/or teachers designated specially for this kind of help, and it could be well enhanced by outside consultation, including telecommunication. These three factors -- the provisioning of time, support, and expert viewpoints -- are essential and their establishment needs to be investigated further.

Third, the project has implications for how prospective teachers need to learn about computers in schools of education. Prospective teachers should model the way we expect them to teach, and thus they should participate extensively in collaborative problem solving in their own learning, with and without computers. They should study the structure and the culture of schooling to better understand the difficulties as well as the possibilities of integrating computing into schools. And they should have actual experience working in school situations, even where such experience is not necessary for certification.